3:4

Effect of early conditioning temperature on tenderness and aging of lamb meat.

BELTRAN J.A., JAIME I., LOPEZ-LORENZO P. and RONCALES P.

Departamento de Tecnología y Bioquímica de los Alimentos. Facultad de Veterinaria. Universidad de Zaragoza. 50013 ZARAGOZA. SPAIN.

Introduction

The influence of post mortem conditioning temperature has been shown repeatedly to be of paramount importance as to determining meat quality, particularly referred to tenderness (Marsh and Leet, 1966; Locker and Daines, 1976; PetäjÄ et al., 1985) and water holding capacity (Jolley et al., 1980-81; Honikel et al., 1981). Though, most research efforts on this subject are devoted to bovine meat studies, and, except for those related to electrical stimulation of carcasses, only a few of them deal with lamb (Bowling et al., 1978) or mutton meat (Bouton et al., 1973). Furthermore, most papers do not consider the actual temperature attained by muscles on post mortem conditioning nor even take into account the rate of its decrease. Lochner et al. (1980) and Marsh et al. (1980-81) found improved meat tenderness when intact beef carcasses were allowed to maintain high pH and temperature very early post mortem (2-3 hours after slaughter).

We have studied in this paper the effect of conditioning lamb Logissimus dorsi excised muscles at different temperatures -so as to reach within 2-4 hours post mortem internal temperatures of 0, 4, 10, 15, 20 and 36°C- upon meat tenderness, measured over seven days of aging. Thus the aim of this study is to get a better knowledge of the influence of early reaching conditioning temperatures on lamb meat quality.

Material and Methods

Pairs of Longissimus muscles were obtained from lambs of 9-12 Kg carcass weight -as are most commonly slaughtered in Spain- within 30 min post mortem, trimmed of visible fat, wrapped in polyethylene bags and immediately stored in a thermostatized bath so as to reach internal muscle temperatures of 0, 4, 10, 15, 20 and 36°C. One muscle of each pair was used for measuring pH, ATP and degree of shortening until rigor onset, while the corresponding muscle from the other carcass side allowed the continuous monitoring of internal temperature by using a thermocouple. After rigor was completed, the latter was stored in a cooler and aged for 7 days at a constant temperature for all prerigor treatments of 4°C. At least three pairs of muscles were used for each conditioning temperature treatment.

Measurement of shortening. Several bundles of muscle fibers of about 0.3 cm diameter and 5 cm length were excised from whole muscles within one hour post mortem, before submerging them into the conditioning bath, and their exact length was measured. The bundles were then kept in the bath until rigor onset, when length was measured again. Shortening is expressed as the percentage of the difference between initial and final lengths related to initial value.

pH of tissue. Measurement of pH was accomplished by homogenising 3 g of muscle tissue in 20 ml distilled water for 15 s. pH of the homogenate was determined with a Crison pH-meter and a combined glass electrode.

Determination of ATP. ATP concentration was determined enzymatically according to Jaworek et al. (1970) in neutralized perchloric extracts of muscle tissue.

Water holding capacity. Water holding capacity was determined using two different systems: compression and cooking loss. The press method was carried out according to Grau and Hamm (1957) and cooking loss as described by Yu Bang Lee et al. (1978).

Tenderness evaluation. Overall tenderness was evaluated by an eight-member semi-trained taste panel. Sensory scores were rated on a 9-point scale; 9 denoted extremely tender and 1 denoted extremely tough. Evaluation samples consisted of 0.7 cm thick loin steaks, trimmed of visible connective tissue and fried with very little oil on a frying pan to an internal temperature of 70°C -cooking method most frequently used in Spain-. Steaks were cut in four sections and two of them, selected at random, presented to each panel member for evaluation.

SDS-gel electrophoresis. We employed a modification of Laemmli procedure according to Greaser et al. (1983). This system uses a 1.5 mm thick slab gel consisting of a 15% polyacrylamide resolving gel and a 3% stacking gel. The acrylamide:bisacrylamide crosslinker ratio is 200:1 in the resolving gel and 20:1 in the stacking gel. Electrophoresis was performed at a constant voltage of 120 V at the stacking gel and then at 250 V for about 5 h. Gels were stained using a solution of Coomassie blue R 250 and destained until background was clear. Myofibrils were essentially prepared according to the procedure described by Olson et al. (1976). Myofibril suspensions were dissolved in 0.05 M Tris-HCl buffer (pH 6.8) and boiled for 5 min in the presence of 6% SDS. After heating, 40% sucrose was added in a ratio of 1:3 (v/v) and the final protein concentration was adjusted to 10 mg/ml. 10 ul of these myofibril solutions were applied to the gels.

Results and Discussion

Although corresponding results are not shown, muscles attained in all cases internal temperatures of 0, 4, 10, 15, 20 and 36°C, respectively to each conditioning treatment, within 2-4 hours post mortem. Thus we may be sure that most time required by muscles to undergo the biochemical changes which lead to rigor onset occur at the desired temperature of conditioning. It is obvious that such a rapid chilling rate, in the case of lower temperatures, is not to be expected in usual handling of beef or mutton carcasses after slaughter; conditions can however approach those here described when very lean 8-12 Kg weight lamb carcasses are considered.

Table 1 shows sensory panel scores for meat tenderness at 1st, 4th and 7th days of aging related to four conditioning temperature treatments; temperatures within the range 10-20 °C are considered as an homogeneous group since results behave almost identically. From the observation of results shown one may come to several conclusions. First, almost all conditioning treatments lead to tenderness scores significantly different at least at the 5% level of probability, and this is specially true at the 7th day of aging. Second, aging causes in all cases a tenderising effect, which is more pronounced at lower temperatures of conditioning. Third and most important, tenderness either at 1st, 4th or 7th day of aging is ordered according to the following outline: 0°C > 10-20°C > 4°C > 36°C. These results are indeed surprising since, although when only temperatures higher than 4°C are considered exists some disagreement in literature about tenderness reached (Bouton et al., 1973; Bowling et al., 1978; Lochner et al., 1980; PetäjÄ et al., 1985), it is generally accepted that lower temperatures cause

Table 1.- Overall tenderness panel scores for lamb meat aging for 7 days after different prerigor conditioning temperature treatments. (n =32-76)[a]

Prerigor conditioning temperature (°C)	Days of aging 1	4	7
0	4.9a ± 0.91	5.9a ± 0.86	7.2a ± 0.74
4	3.7b ± 0.62	5.0b ± 0.92	6.0b ± 0.67
10-20	4.55a ± 1.19	5.5ab ± 0.93	6.45c ± 0.95
36	3.1c ± 0.91	3.8c ± 0.83	4.8d ± 0.91

[a]Mean values not followed by the same letter within a column are significantly different at the 5% level of probability.

cold shortening to appear (Honikel et al., 1983) and as a consequence meat becomes tough (Marsh and Leet, 1966). However, as far as we know they have not as yet been reported results on lamb meat tenderness after such a rapid chill conditioning.

In order to compare these results with proteolytical activity on myofibrillar proteins, which has been related to meat tenderness by many authors (Bechtel and Parrish, 1983; Goll et al., 1983; Yates et al., 1983), SDS-polyacrylamide gel electrophoresis of muscle at rigor and 1st, 4th and 7th day of aging for 0, 4 and 15°C conditioning temperature treatments was carried out. Figure 1 shows one example for each prerigor treatment of electrophoretic patterns we obtained.

As may be clearly seen in Figure 1 some modifications along aging are evident in all three electrophoretic patterns, with different behaviour for each temperature treatment. 55000 Dalton disappears in all cases, although disappearance is complete for 0°C at the first day of aging, while 7 days are necessary for 4 and 15°C. Troponin T behaves in a similar manner, disappearing for 0°C at the 4th day, while for 4 and 15°C seven days of aging are needed. 39000 Dalton band disappears at the 7th day for 0°C treatments, while for 4 and 15°C is not complete within this time. On the other hand, proteolytically originated bands appear in all three cases too; within the range of 32000 to 26500 Dalton four bands are clearly visible at least after 4 days of aging. With no doubt these bands are more intense for 0°C than for 15°C, and these latter much more than for 4°C. Even a stumped 24500 Dalton band can be hardly seen at 0 and 15°C patterns.

These results agree in general with that reported previously for beef meat aging (Bechtel and Parrish, 1985; Yates et al., 1983), even those for 0°C(Koohmaraie etal., 1984); thus according to Goll et al. (1983) they must be considered as a demonstration of meat tenderness to be ordered following the outline 0°C >15°C>4°C, as was already stated. Differences found in electrophoretic patterns with those obtained from beef muscles will not be here discussed.

Table 2 presents results of some physical properties of muscle measured at rigor onset for each prerigor treatment. If we observe the results shown for all parameters measured, one may conclude that lamb meat tenderness scores and electrophoretic patterns obtained for the different prerigor treatments are independent from them. In fact, tenderness appear to be absolutely independent of degree of shortening, in disagreement with Marsh and Leet

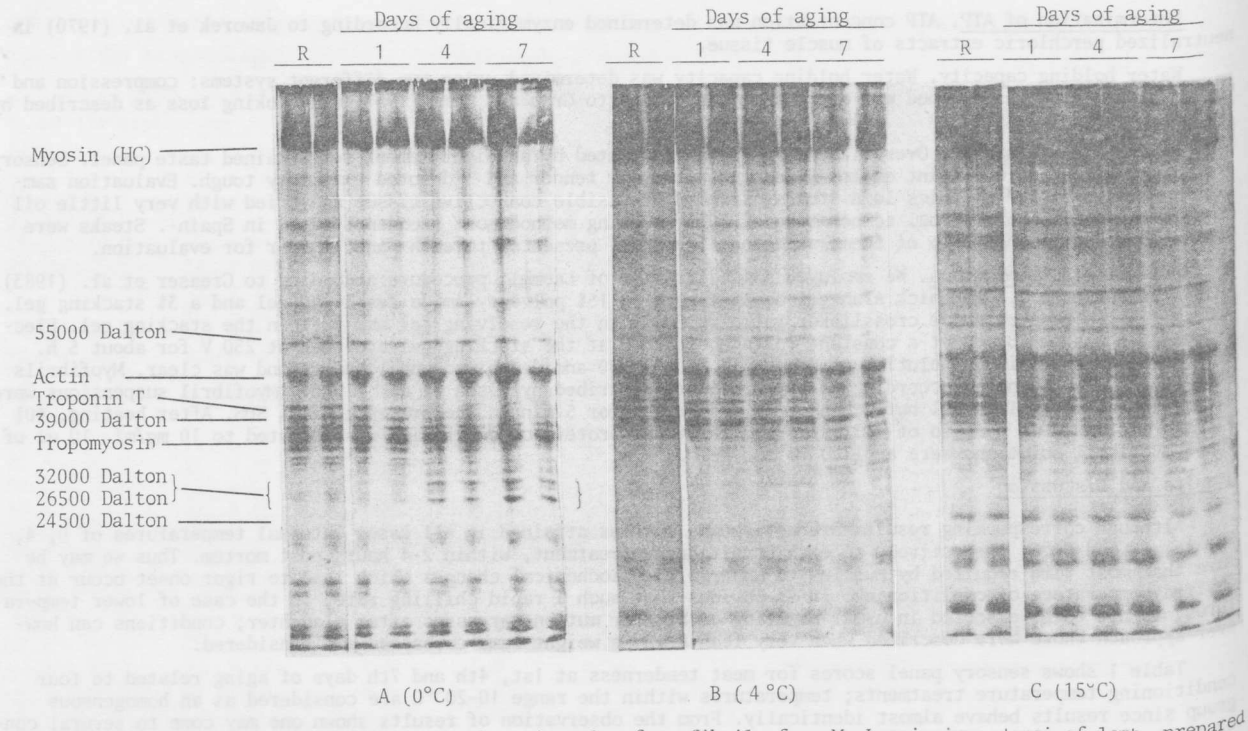

Figure 1.- SDS-15% polyacrylamide electrophoretic gels of myofibrils from M. Longissimus dorsi of lamb, prepared as described in Material and Methods. Samples were taken at rigor onset (R) and 1st, 4th and 7th day of aging for each prerigor conditioning temperature treatment (A: 0°C; B: 4°C; C: 15°C).

Table 2.- Mean values of some physical properties of lamb Longissimus muscle at rigor onset[a] for different prerigor conditioning temperature treatments.

Prerigor conditioning temperature (°C)	Rigor			
	pH	Shortening (%)	WHC[b]	CL[b]
0	5.85	33.1	24.9	38.9
4	5.57	32.8	30.1	38.2
10-20	5.54	12.0	30.8	38.6
36	5.90	23.0	34.8	37.8

[a]Rigor onset as determined by full ATP depletion.

[b]Water holding capacity (WHC) and Cooking loss (CL) are expressed as percent weight of the muscle sample released after the corresponding treatment of pressing or cooking.

(1966) and many other authors, since muscle shortens to the same percentage at 0 and 4°C, and also of degree of cooking loss. Water holding capacity (press method) is higher for 0°C treatment than for any other temperature, what disagrees with results reported by Jolley et al. (1980-81), but could explain in part the high tenderness scores obtained for this treatment, since juiciness perception was not discriminated from overall tenderness by panel members. In any case, according to Bouton et al.(1971) this higher water holding capacity would be in agreement with the higher value of pH reached at rigor onset.

In this sense, the high pH for 0°C as compared with 4 and 10-20 °C treatment groups may explain the observed increase in tenderness at that temperature, since the proteolytic activity of "calcium activated neutral protease" (CANP) has been demonstrated to be highly dependent of muscle pH (Goll et al., 1983). Furthermore, an increased Ca^{++} concentration within myofibrils is needed for CANP activity (Goll et al., 1983), which is easily reached at lowest conditioning temperatures by sarcoplasmic reticulum release according to Kanda et al. (1977) and to some preliminary results obtained by ourselves not shown here. Obviously, further research is needed in order to explain the results presented in this paper.

Conclusions

Early conditioning of lamb Longissimus dorsi at an internal muscle temperature of 0°C causes an increased tenderness of meat when compared to any other temperature of conditioning. Tenderness appear to be independent of muscle shortening.

Aknowledgements

The authors wish to thank the Diputación General de Aragón for the partial support of this research.

References

-Bechtel,P.J. and Parrish,F.C.Jr. (1983). J.Food Sci. 48:294.
-Bouton,P.E.;Harris,P.V.;Shorthose,W.R. and Baxter,R.I. (1973). J.Food Sci. 38:932.
-Bowling,R.A.;Smith,G.C.;Dutson,D.R. and Carpenter,Z.L. (1978). J.Food Sci. 43:502.
-Goll,D.E.,Otsuka,Y.,Nagainis,P.A.,Shannon,J.D.,Sathe,S.K.,Muguruma,M. (1983) J. Food Biochem. 7:137.
-Grau,R. and Hamm,R. (1957) Z. Lebensmitteluntersforsch. 105:446.
-Greaser,M.L.,Yates,L.D.,Krzywicki,K. and Roelke,D.L. (1983) Reciprocal Meat Conference Proceedings 36:87.
-Honikel,K.O.,Hamid,A.,Fischer,C. and Hamm,R. (1981) J. Food Sci. 46:23.
-Honikel,K.O.,Roncalés,P. and Hamm,R. (1983) Meat Sci. 8:221.
-Jaworek,D.,Gruber,W. and Bergmeyer,H.U. (1970) . Methodem der enzymatischen Analyse.Ed. Bergmeyer,H.U. p.2020 Verlag Chemis,Weinheim.
-Jolley,P.D.,Honikel,K.O. and Hamm,R. (1980-81) Meat Sci. 5:99.
-Kanda,T.,Pearson,A.M. and Merkel,R.A. (1977) Food Chem. 2:253.
-Koohmaraie,M.,Kennick,W.H.,Anglemier,A.F.,Elgasim,E.A. and Jones,T.K. (1984) J. Food Sci. 49:290.
-Locker,R.H. and Daines,G.J. (1976) J. Sci. Food Agri. 27:193.
-Lochner,J.V.,Kauffman,R.G. and Marsh,B.B. (1980) Meat Sci. 4:227.
-Marsh,B.B.,Lochner,J.V.,Takahashi,G. and Kragness,D.D. (1980-81) Meat Sci. 5:479.
-Olson,D.G.,Parrish,F.C. and Stromer,M.H. (1976) J. Food Sci. 41:1036.
-Petäjä,E.,Kukkonen,E. and Puolanne,E. (1985) Meat Sci. 12:145.
-Yates,L.D.,Dutson,T.R.,Caldwell,J. and Carpenter,Z.L. (1983) Meat Sci. 9:157.
-Yu Bang Lee,Rickansrud,D.A.,Hagberg,E.C. and Forsythe,R.H. (1978) J. Food Sci. 43:35.